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AVAILABILITY OF CLEAN WATER AND DISCHARGE RELIABLE FOR HOUSING TAMAN ARGO SUBUR CISOKA, TANGERANG DISTRICT

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ABSTRACT

The problem of water availability is an important issue in the development of a residential area, because the availability of water resources is the supporting capacity for the development of a residential area. Adequate water availability for now and predictions of future water availability are very important to know for ensuring an area that is feasible for development. The purpose of this study is to determine the amount of water availability through the method of calculating the water balance and calculating the mainstay discharge to find out whether the water needs are fulfilled or not. Household water consumption is one of the biggest contributors to the water crisis in residential areas. For this reason, it is necessary to have information that has high accuracy regarding the existence of water sources and the amount of water reserves owned by a location. The water balance is one way to determine the availability of water in an area so that it can be calculated whether the location will experience a water crisis or not. Calculation of water balance using the FJ Mock method can provide the information needed whether an area has a surplus of water or not and can be used to calculate the mainstay discharge which is useful for distributing water to residents. Making reservoirs or tendons is an alternative to overcome the occurrence of a water crisis when the dry season comes because often residential areas experience water shortage problems. For this reason, a calculation is made regarding the amount of water debit produced by the water reservoir made by the manager and the amount of surplus water is based on the monthly average method. The results of the calculation of the FJ Mock discharge can be seen that the resulting maximum discharge is 0.504 m^3/second and the minimum discharge is 0.069 m^3 / sec. The results of the reliable discharge calculation show that the water discharge is still acceptable or meets the criteria because even though in August the water discharge that was achieved was only 0.069 m^3/sec, this amount still meets the requirements at a reliability value of 99% and at an error value of 1%. These results provide evidence that the discharge generated by the two residential tendons of Taman Argo Subur still meets the requirements.

Keywords: water availability, FJ mock, reliable discharge.

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INTRODUCTION

Clean water is an important part of human life, so the availability of clean water is very influential for human life. The effect of availability of clean water is not only on household needs, but has an effect on the social, economic, and public facilities sectors, in line with the population growth rate (Dwi, Tanudjaja and Hendratta, 2016). Water is also needed for food availability and irrigation, which continues to increase as the population increases. The need for water is directly proportional to the needs of the population (Hidayat,

The impact of human consumption on global water resources can be mapped using a water footprint. The concept of a water footprint was proposed and defined as "a measure of human appropriation of freshwater resources". The water footprint is an indicator of water use in which water consumption and pollution are included; they can also be applied to extend water resource evaluation systems and provide water use information for decision-making. The environmental crisis occurs due to excessive use of natural resources. Utilization of natural resources that do not pay attention to sustainable elements. Excessive natural resource consumption patterns can lead to natural resource crises. (Amalia and Sugiri, 2014).

Groundwater resources are one of the resources that have experienced a crisis in recent years. Population development and the increasing population density in urban areas has resulted in a decrease in the amount of groundwater due to the lack of catchment areas. Therefore, it is very important to know the pattern of household water consumption for urban communities and to search for alternative sources of water, one of which is by utilizing rainwater.

Efforts to utilize rainwater can be made by calculating the water balance. The water balance is part of the science of hydro meteorology which describes the relationship between inflow and outflow in an area during a certain period. In its calculations, the water balance can describe rainfall that is accommodated in the recharge area, re-evaporation as evapotranspiration, water flowing on the surface as *surface direct runoff off* and groundwater infiltration (Rinaldi, 2016b).

In addition to calculating the water balance, the amount of rainfall can also be used to calculate the magnitude of the planned discharge. Design discharge (Q) is discharged with a certain return period which is expected to pass through a river (Kamiana, 2011)

Taman Argo Subur Housing is a subsidized housing complex located in Cisoka, Tangerang Regency

and has a land area of +/- 35 Ha. This housing is still developing because the land owned has not been fully utilized, in fact the developer has targeted an area expansion of up to 100 ha (Figure-1)

Figure-1. Map of Taman Argo Subur housing.

PDAM as a state company that provides clean water to the community has limitations in providing clean water. Data from PDAM Tirta Kerta Raharja, Banten Regency, shows the number of customers served is 124,000 connections (PDAM, 2016).

To meet water needs, apart from relying on clean water distribution from the PDAM, the Taman Argo Subur housing complex in Cisoka, Tangerang Regency, will build a reservoir that utilizes rainwater and groundwater. For this reason, calculations are needed to find out the availability of water in the Tangerang Regency area, specifically in the Cisoka District area.

The availability of water in an area can be estimated using the water balance. The water balance calculates the availability of water (surplus or deficit) by utilizing climatological data such as rainfall, temperature, humidity and solar radiation.

METHODOLOGY

This research was conducted at Taman Argo Subur Housing Complex, Cisoka, Tangerang Regency.
The hydrologic cycle can be expressed quantitatively based on the principle of mass conservation or known as the water balance equation. In general, the water balance equation can be written in the form (Triatmodjo, 2016)

$$P + Q_i + G_i - E - T - Q_o - G_o - \frac{\Delta S}{\Delta t}\Delta = 0 \quad (1)$$

Where:
Q : Precipitation
Qi, Qo : inflow and outflow discharge
Gi, Go : the inflow and outflow of groundwater
E : Evaporation
Q : Evapotranspiration
ΔS : change in storage volume for the interval time Δt

The modified Penman formula is used to calculate evapotranspiration

$$ETo = C\,(W \times Rn + (1 - W) \times f(U) \times (ea - ed) \quad (2)$$

Where:
ETo = daily potential evapotranspiration (mm/day)
C = correction factor,
W = a factor related to temperature and temperature,
Rn = net wave radiation (mm/day),
f(U) = a factor that depends on wind speed (km/day),
ea = saturated vapor pressure value (m bar),
ed = real water vapor pressure value (m bar).

Data processing for the calculations of the mainstay discharge uses the FJ Mock method.

$$Q = X + K.S \quad (3)$$

Where:
Q = Flow rate (mm)
X = Monthly Average Debit
S = Standard Deviation

Parameter data used for water balance calculations are:

a. Rainfall data
b. Air temperature data
c. Soil physical properties data
d. Vegetation cover data

Rainfall intensity is used to help predict future water availability.

$$I = \frac{R_{24}}{24}\left(\frac{24}{t}\right)^{2/3} \quad (4)$$

Where:
I = rainfall intensity
R = hourly rainfall
t = length of rain

RESULTS

One of the conditions for an area to be developed into a residential area is having sufficient water resources. To find out the water resources owned by an area, a water balance calculation can be carried out using climatological data. The climatological data used in this study were obtained from the Tangerang Regency BPS website. The data used is data for the last ten years (2012-2021).

Taman Argo Subur housing is located in Cisoka District, Tangerang Regency. One of the data needed to calculate the water balance is rainfall data.

Table-1. Average Rainfall for Tangerang Regency for the 2012 - 2021 period.

Year	Average Rainfall (mm)
2012	100.53
2013	197.08
2014	126.75
2015	108.93
2016	251.26
2017	256.87
2018	167.71
2019	139.13
2020	270.75
2021	248.15

Source: BPS, 2022

Table-1 shows the amount of average rainfall that occurred in Tangerang Regency during the period 2012 to 2021. The rainfall that occurred in the Tangerang Regency area is an indication of the amount of groundwater reserves in the area. In addition to rainfall, data on climate, temperature and solar radiation are needed to determine the amount of water reserves in the region (Figure-2).

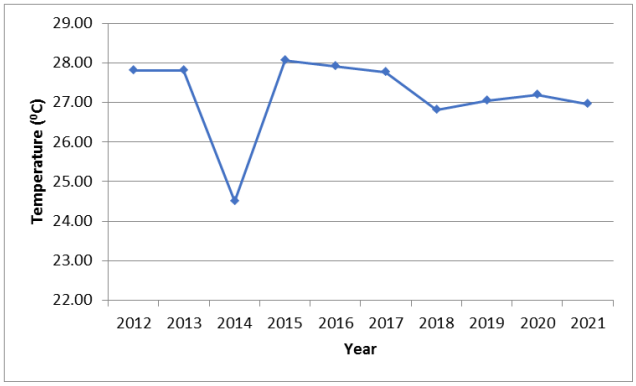

Figure-2. Average Temperature for the Period 2012 - 2021.

Table-2. Evapotranspiration Value 2012-2021.

Year	Total Evapotranspiration
2012	1,878.05
2013	1,878.05
2014	1,176.40
2015	1,942.23
2016	1,905.39
2017	1,869.56
2018	1,639.66
2019	1,692.54
2020	1,726.29

By using the FJ Mock method to calculate the amount of discharge in each reservoir used in Argo Subur Park, evapotranspiration data is needed. The results of the evapotranspiration calculation for the 2012 - 2021 period can be seen in Table-2.

Evapotranspiration is data which is the process by which water turns into water vapor and moves from the surface of the water. Transpiration is the process of evaporation of water contained in plant layers to evaporate into the atmosphere. Solar radiation, air temperature, air humidity and wind must be considered when determining the transpiration value (Rinaldi, 2016a).

Table-3. Average discharge (m^3/sec).

Year	Average Discharge (m^3/sec)											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
2012	0.149	0.056	0.000	0.042	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2013	0.277	0.083	0.066	0.000	0.105	0.000	0.090	0.000	0.000	0.000	0.062	0.144
2014	0.291	0.138	0.004	0.000	0.009	0.000	0.172	0.000	0.000	0.000	0.065	0.014
2015	0.227	0.094	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2016	0.012	0.156	0.137	0.176	0.000	0.000	0.034	0.050	0.044	0.181	0.490	0.000
2017	0.100	0.208	0.109	0.205	0.150	0.193	0.153	0.000	0.100	0.224	0.000	0.026
2018	0.000	0.160	0.082	0.197	0.041	0.035	0.000	0.000	0.000	0.000	0.139	0.077
2019	0.149	0.182	0.000	-0.018	0.216	0.000	0.000	0.000	0.000	0.000	0.000	0.021
2020	0.069	0.504	0.239	0.128	0.139	0.000	0.000	0.000	0.116	0.408	0.121	0.066
2021	0.180	0.397	0.000	0.086	0.212	0.200	0.001	0.069	0.000	0.036	0.214	0.131
Average 2	0.145	0.198	0.064	0.082	0.087	0.043	0.000	0.012	0.000	0.085	0.109	0.048

Source: Calculation Results, 2023

After obtaining the evapotranspiration value, the amount of water surplus and water discharge for each reservoir can be calculated. Taman Argo Subur housing has two water reservoirs with each reservoir having the following area:

- Reservoir 1 : 1.37 Km^2
- Reservoir 2 : 1.5 Km^2

The data in Table-3 shows the average monthly discharge for the two reservoirs used in the Taman Argo Subur Cisoka Housing Complex, Tangerang Regency.

The average monthly discharge in Table-3 is used to calculate the mainstay of discharge at Taman Argo Subur Cisoka Housing, Tangerang Regency. This method is most often used because the reliability of the discharge is calculated from January to December, so it can better describe the reliability in the dry and rainy seasons (Mayasari, 2017).

The mainstay debit is the amount of discharge available to meet water needs with a risk of failure that has been calculated and aims to determine the planned discharge that is expected to always be available in the river (Soemarto, 1999). The amount of reliable discharge for various purposes can be seen in Table-4.

Table-4. Mainstay debt value.

Activity	Reliability
Provision of drinking water	99%
Industrial water supply	95 - 98%
Provision of irrigation	80%
Semi-humid climate area	70 - 85%
Dry climate area	89 - 95%
Hydroelectric power plant	85 - 90%

Source: (Limantara, 2018)

Reliability based on discharge conditions can be divided into 4, namely (Mayasari, 2017):

a) Dry season water discharge, namely the debit exceeded by debits of 355 days in 1 year with reliability: (355/365) X 100% = 97.3%.
b) Low water discharge, that is, discharge exceeded by debits of 275 days in 1 year with reliability: (275/365) X 100% = 75.3%.
c) The normal water debit is the debit that is exceeded by debits of 185 days in 1 year with a reliability of (185/365) X 100% = 50.7 %.
d) Sufficient water debit, namely the debit which is exceeded by debits of 95 days in 1 year with reliability: (95/365) X 100% = 26.0%.

In this study, the calculation of the mainstay debit is carried out for the purpose of supplying drinking water. The management of Taman Argo Subur has 2 water reservoirs which are used as a source of clean water and provided to residents through drinking water distribution

pipelines. Based on Table-4, the reliability value used is 99%.

Using Table-4 above, the mainstay discharge for January can be made as shown in Table-5.

Table-5. Debit mainstay of FJ mock method.

No	P	January (m^3/s)
1	9,091	0.000
2	18,182	0.012
3	27,273	0.069
4	36,364	0.100
5	45,455	0.149
6	54,545	0.149
7	63,636	0.180
8	72,727	0.227
9	81,818	0.277
10	90,909	0.291
Q99		0.291

The mainstay debit for drinking water or clean water supply uses Q99 so that the debit used is the highest debit. In January it can be seen that the minimum discharge is 0.000 and the maximum discharge is 0.291 m^3/second. The discharge data contained in Table-4 is arranged based on the lowest value to the highest value and follows the magnitude of the opportunity that has been determined. For the following months the reliable debit value is obtained in the same way as obtained in January.

The results of calculating the mainstay discharge for Taman Argo Subur housing can be seen in Figure-3.

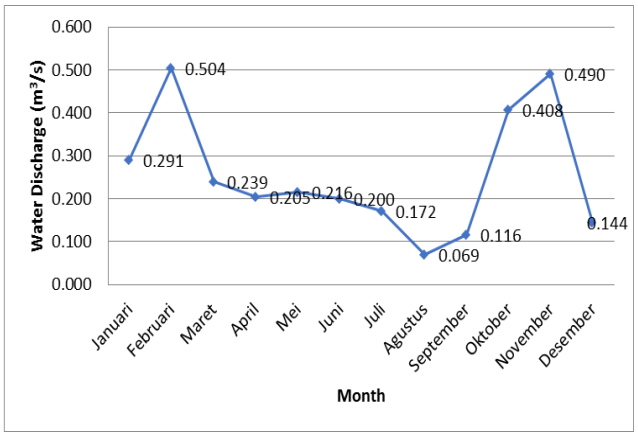

Figure-3. Mainstay debt value.

Based on Figure-3, it can be seen that the lowest reliable discharge is in August, which is 0.069 m^3/second. Based on these results it can be stated that the water debit has met the requirements. When referring to a reliability value of 99% and an error value of 1%, then the lowest reliable discharge value of 0.069 m^3/second is still acceptable (Mayasari (Mayasari, 2017).

Water availability can also be referred to as a water surplus, which is a necessity for residential areas to ensure water availability in the future along with population growth. Water balance calculations in watershed areas can help local governments to take the necessary actions to maintain water availability (Hidayat *et al.*, 2018).

Chandrasasi *et al* (2020) used the FJ Mock method to calculate the water balance in the upper Kanto watershed. The results of water balance calculations using the FJ Mock method show that there is potential for water availability for multi-sector water needs for 25 years (2017-2042 period). The amount of water discharge in the Kanto watershed exceeds the amount of water demand from multi-sectors (domestic and non-domestic) (Chandrasasi, Limantara and Juni, 2020).

Calculation of water demand in the future needs to pay attention to population growth, because the largest use of water still comes from domestic needs. Increasing population growth will increase water demand in the future, so stakeholders need to pay attention to water availability and how to distribute it to the community (Angellina and Farahdiba, 2021).

Apart from paying attention to population growth, in the future the calculation of water needs should be calculated by conducting a survey of housing residents. In regular housing, this is easier to do because generally the facilities and infrastructure of each house are the same and the number of occupants is not too large. Thus it can be seen that the average need for each occupant (Suoth, Purwati and Andiri, 2018).

By using the calculation of the monthly reliable discharge, it will be seen that during the rainy season between October and April the amount of rainfall is high enough to provide sufficient water discharge. On the other hand, during the dry season, which lasts from April to October, the amount of rainfall is generally reduced, and it often does not rain, so that water supplies are reduced.

The calculation of reliable discharge not only provides information regarding the debit needed by a residential area so that its water needs are met, but also serves as a guide regarding whether or not the community's water needs are met when entering peak hours or maximum hours. This is important to consider because the minimum discharge required must also meet the required discharge when maximum usage occurs (Syahputra, 2021).

These results are in line with the research of Setiadi *et al* (2022) who used the FJ Mock method to calculate water availability in Jatiluhur Estate housing, Purwakarta Regency. The results of FJ Mock's calculations show that the availability of water in the area is sufficient for the next 30 years. However, there are very large fluctuations in water discharge between the dry season and the rainy season, so that attention is needed for water management for the next 20 years (Setiadi, Wijayanti and Cahyono, 2022)

The results of this study are in line with Ariswandi's research (2021) which shows that the FJ Mock method provides better results than other methods in terms of calculating reliable debits (Ariswandi, 2021). The availability of reliable water used is adjusted to the existence of irrigation areas. If there is an irrigation area, the reliable water supply uses a reliable debit of 80%, but if there is no irrigation area, then the reliable water availability uses a reliable debit of 90% (Sudinda, 2019).

In this study, the mainstay debit used is 99% because the debit calculation is carried out for drinking water needs. The water reservoir prepared by the Taman Argo Subur housing manager is intended as a water reserve when the PAM water or groundwater cannot meet the needs of the occupants. The use of dual reservoirs is an alternative to meet the needs of clean water for the residents of Argo Subur Park (Siregar *et al.*, 2020).

Water discharge in watersheds (DAS) is calculated to provide information about water availability in an area. The availability of water in an area is important for housing development (Biantoro *et al.*, 2022). Water discharge can be predicted for more than 100 years by utilizing data relating to land management, catchment areas and rainfall (Biantoro, Wahyudi and Niam, 2022).

Expansion of residential areas not only requires carrying capacity in the form of water availability, but also needs to pay attention to environmental conditions. Provision of a tendon or reservoir by the manager of Taman Argo Subur Housing is one of the efforts to accommodate excess water during the rainy season. Excess rainwater that is not absorbed into the ground will cause flooding in an area (Biantoro, *et al* 2023)

CONCLUSIONS

Based on the results of the FJ Mock discharge calculation, it can be seen that the resulting maximum discharge is 0.504 m^3 / second and the minimum discharge is 0.069 m^3 / second. The results of the reliable discharge calculation show that the water discharge is still acceptable or meets the criteria because even though in August the water discharge that was achieved was only 0.069 m^3/second, this amount still meets the requirements at a reliability value of 99% and at an error value of 1%. These results provide evidence that the discharge generated by the two residential tendons of Taman Argo Subur still meets the requirements.

REFERENCES

Amalia B. I. and Sugiri A. 2014. Ketersediaan Air Bersih dan Perubahan Iklim : Studi Krisi Air di KedungKarang Kabupaten Demak. Jurnal Teknik PWK. 3(2): 295-302.

Angellina R. and Farahdiba A. U. 2021. Analisis Kebutuhan Air Bersih Berdasarkan Jumlah Penduduk Di Desa Gedangkulut Kab. Gresik Melalui Pendekatan Sistem Dinamis', UPN JAwa Timur. 2(1): 103-109.

Ariswandi D. 2021. Analisa Ketersediaan Debit Air Sungai Cibuni menggunakan Metode F.J Mock dan Nreca', Jurnal Student Teknik Sipil. 3(2): 344-356.

Biantoro, Agung Wahyudi., S I Wahyudi, M F Niam and A G Mahardika. 2022. Analysis of Ciliwung river flood debit and city flood anticipation using floods early detection system (FEDS). IOP Conference Series: Earth and Environmental Science, pp. 1-12. doi: 10.1088/1755-1315/955/1/012011.

Biantoro, Agung Wahyudi., SI Wahyudi, S. I. and Faiqun, M. 2023. Analysis of Time of Concentration Estimates Using Some Methods and HEC RAS. Civil Engineering and Architecture, 11(1): 486-497. doi: 10.13189/cea.2023.110137.

Biantoro Agung Wahyudi., SI Wahyudi and MF Niam. 2022. New Method for Floods Early Detection using some Sensors based on IoT Technology. ARPN Journal of Engineering and Applied Sciences. 17(14): 1429-1436.

Chandrasasi D., Limantara L. M. and Juni R. W. 2020. 'Analysis using the F . J . Mock Method for calculation of water balance in the Upper Konto Sub-Watershed Analysis using the F . J . Mock Method for calculation of water balance in the Upper Konto Sub-Watershed', IOP Conf. Series: Earth and Environmental Science, 437. doi: 10.1088/1755-1315/437/1/012019.

Dwi T. Y. G., Tanudjaja L. and Hendratta L. A. 2016. Perencanaan Peningk-tan Kapasitas Produksi Air. Jurnal Sipil Statik. 4(8): 481–491.

Hidayat, A. M. *et al.* 2018. Evaluasi Ketersediaan Sumber Daya Air Berbasis Metode Neraca Thornhwaite Mather untuk Pendugaan Surplus dan Defisit air di Pulau Jawa', Prosiding SNFA (Seminar Nasional Fisika dan Aplikasinya). pp. 35-46.

Hidayat Acep. and M. Hidayatullah. 2020. Analysis of Crop Pattern Plant and Irrigation Water Needs in Pauh Tinggi Irigation Network Planning, Pauh Tinggi Village, Kerinci District, Jambi. JIEEB nternational ournal of ntegrated ducation, ngineering and usiness ISSN 2615-1596 ISSN 2615-2312, 3(2): 104-125. https://doi.org/10.29138/ijieeb.v3i2.1171

Kamiana I. M. 2011. Teknik Perhitungan Debit Rencana. Edisi Pert. Yogyakarta: Graha Ilmu.

Limantara, L. M. 2018. Rekayasa Hidrologi. Edisi Revi. Yogyakarta: Andi.

Mayasari D. 2017. Analisa Statistik Debit Banjir Dan Debit Andalan Sungai Komering Sumatera Selatan. Jurnal Forum Mekanika. 6(2): 88-98.

PDAM. 2016. Kinerja PDAM 2016. Jakarta. Available at: http://sim.ciptakarya.pu.go.id/bppspam/list_category/91.

Rinaldi, A. 2016a. Modul Perhitungan Neraca Air Studi Kasus Kota Cirebon. (May). doi: 10.13140/RG.2.1.1193.0481.

Rinaldi, A. 2016b. MODUL PERHITUNGAN NERACA AIR Program Magister Teknik Airtanah Fakultas Ilmu dan Teknologi Kebumian (FITB) Institut Teknologi Bandung. (November 2015). doi: 10.13140/RG.2.1.1193.0481.

Setiadi P. A., Wijayanti Y. and Cahyono C. 2022. FJ. Mock Method for Hydrological model in Water Reliability Study at Jatiluhur Estate, Purwakarta FJ. Mock Method for Hydrological model in Water Reliability Study at Jatiluhur Estate, Purwakarta. doi: 10.1088/1755-1315/998/1/012003.

Siregar C. A. *et al*. 2020. Automation and Control System on Water Level of Reservoir based on Microcontroller and Blynk. 2020 14th International Conference on Telecommunication Systems, Services, and Applications (TSSA. doi: 10.1109/TSSA51342.2020.9310836.

Soemarto C. 1999. Hidrologi Teknik. Edisi Kedu. Jakarta: Erlangga.

Sudinda T. W. 2019. Penentuan Debit Andalan dengan Metode F.J Mock di Daerah Aliran Sungai Cisadane. Jurnal Air Indonesia. 11(1): 15-24.

Suoth A. E., Purwati S. U. and Andiri Y. 2018. Pola konsymsi air pada perumahan teratur. Ecolab. 12(2): 53-102.

Syahputra B. 2021. Penentuan Faktor Jam Puncak dan Harian Maksimum Terhadap Pola Pemakaian Air DOmestik Di Kecamatan Kalasan, Sleman, Yogyakarta. pp. 1-15.

Triatmodjo B. 2016. Hidrologi Terapan. Yogyakarta: Beta Offset.